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BOONTON 92B

Instruction Manual

Model 92B

R.F. Millivoltmeter

01/83

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CHAPTER I

INTRODUCTION

1.1 GENERAL

The 92B R.F. Millivoltmeter provides an accurate read-out of measurements from the low radio frequencies to the gigahertz region, over a voltage range of 200 μV to 3 volts. It is a programmable, solid-state instrument of high sensitivity and accuracy, characterized by high input impedance (see Figures 1 and 2), excellent stability, and low noise.

The 92B exhibits true r.m.s. response for input signals up to 30 millivolts, gradually approaching peak-to-peak above this level. The meter, however, is calibrated to indicate r.m.s. of a sine wave above 30 mV.

Input and output connections for external control and read-out are provided by a 22-pin card-edge connector at the rear of the instrument.

A linear d.c. output, the level of which is proportional to the r.f. input voltage, is also provided at a rear connector. This d.c. output may be used to drive a recorder, a remote indicator, or other analog devices.

The voltmeter offers a convenient and accurate means for making a wide variety of measurements. Typical uses of this instrument include:

Transistor testing--to measure β, f_t, and other transistor parameters.

S.W.R. and return-loss measurements--using bridge methods, directional couplers, and adjustable or slotted lines.

Gain and loss measurements in wide-band amplifiers, including such design characteristics as stage gain, flatness of the pass band, upper cut-off or corner frequency, negative-feedback factors, and other parameters.

Proper adjustment of tuned circuits in narrow-band amplifiers.

The adjustment, measurement of performance, and evaluation of r.f.-filter parameters.

Measurement of s.w.r or return-loss and attenuation of r.f. attenuators.

Measurement of output levels of signal generators, adjustment of baluns, harmonic distortion of r.f. signals, and adjustment of circuits for minimum voltage (null), or maximum voltage (peak).

The 92B is available in several optional configurations with a basic accuracy of 1% of reading +1% f.s. The standard features of the instrument are:

Remote programmability.

Capability of measuring from 200 µV to 3 V*, from 10 kHz to 1.2 GHz.

True r.m.s. response to 30 mV**.

Convenient push-button ranging.

D.C. analog output.

High input resistance; low input capacitance.

Overload protection to 400 V, d.c., and 10 V, a.c.

S.W.R. less than 1.2 up to 1.2 GHz.

*To 300 V, up to 700 MHz, with accessory 100:1 divider.
**To 3 V, up to 700 MHz, with accessory 100:1 divider.

The characteristics of the instrument include: high reliability, fast warm-up (one minute, typical), long intervals between calibrations, plug-in p.c. boards for ease in servicing or modifying, light weight, and other advantages of solid-state design.

1.2 EQUIPMENT DESCRIPTION

The Model 92B is basically a programmable analog instrument with linear d.c. output. It is available with accessories as described in Chapter II. Logic-level programming, TTL/DTL-compatible, is standard.

The instrument is sensitive, accurate, sturdily constructed, and protected against overloads. It will perform over extended periods of time without failure or need for recalibration. It is packaged as a compact bench instrument that can be easily mounted in a standard 19-inch rack using an optional rack-mounting kit.

Important input and accuracy specifications are reproduced on a reference plate fastened to the exterior top cover of the instrument. Clips for holding out-of-use accessories are provided at the rear of the instrument. Calibration instructions are reproduced on the underside of the top cover of the instrument.

Standard accessories supplied with the Voltmeter include one each of the following:

Model 91-12F R.F. Probe with low-noise cable and connector.

Model 91-8B 50 ohm BNC Adapter.

Model 91-13B Probe Tip (removable), with grounding-clip lead.

1.2.1 Frequency Capability

The calibrated frequency range of the Model 92B extends from 10 kHz to 1.2 GHz, with uncalibrated response to beyond 8 GHz. Relative accuracy* above 1.2 GHz is typically ± 0.5 dB.

*Relative accuracy refers to the differential between two measured levels--without regard to the absolute accuracy of either measurement. A measurement of a 100-mV signal at 8 GHz may indicate 20 mV on the meter; then a 50-mV signal, at that same frequency, will be indicated as 10 mV, within about 0.5 dB (5.9%).

A Model 91-8B 50 ohm BNC adapter is supplied as a standard accessory with the instrument for 50 ohm voltage measurements up to 600 MHz. A correction curve, Figure 6A, is included for frequencies above 50 MHz. For higher-frequency measurements and for through-line voltage measurements, the optional accessory, Model 91-14A Tee Adapter is recommended. It is designed to compensate for the r.f.-probe capacitance and to present a good s.w.r. (better than 1.15) up to 1.2 GHz. It may be used in conjunction with the Model 91-15A 50 ohm load for terminated voltage measurements. In a coaxial line its insertion loss is low; however, a chart (Figure 6B) is supplied, showing loss vs. frequency. See Figure 4 for typical s.w.r.

An optional accessory, Model 91-4C R.F. Probe, has a frequency range of 1 kHz to 250 MHz for lower-frequency applications

1.2.2 Voltage Capability

The voltmeter has eight ranges, from 1 mV, f.s., to 3 V, f.s., arranged in a 1-3-10 sequence. No attenuator attachments are required for measurements up to 3 V. While this range is ample for most r.f.-voltage measurements, the capability of the instrument can be increased to 300 V (up to 700 MHz), by using the optional accessory, a high-impedance 100:1 Voltage Divider. Use of the 100:1 Voltage Divider also increases the input resistance by a factor of 1000 to 3000, depending upon the input level.

1.2.3 True R.M.S. Response

The Model 92B provides true r.m.s. response for signal inputs below approximately 30 mV (below 3 V, up to 700 MHz, with the 100:1 Voltage Divider). As the input level increases, the waveform response gradually approaches peak-to-peak, calibrated on the indicator in r.m.s. Thus, in addition to making precise sinusoidal voltage measurements at all levels, the instrument measures non-sinusoidal or asymmetrical signals within the r.m.s. region without loss of accuracy.

1.2.4 Low Noise

The Model 92B has been designed and constructed to hold noise from all sources to a minimum.

The probe cable is of special low-noise design; a vigorous flexing causes only momentary, minor deflections on the most-sensitive range. The Probe is not sensitive to shock or vibration; even sharp tapping on the probe barrel causes no visible deflection on any range.

Amplification takes place at 94 Hz, reducing susceptibility to any 50 or 60 Hz line-frequency-related fields. A unique circuit reduces the low-level noise originating from the mechanical chopper and renders the instrument immune to changes in chopper performance that could occur with the passage of time.

1.2.5 Minimal Zero Adjustment

Zero adjustment is not required on the upper five sensitivity ranges of the voltmeter. For measurements on the lower three ranges, the ZERO control is set on the most-sensitive range before operation. This control balances out small thermal voltages in the probe elements and, once adjusted, requires only infrequent checking during the course of subsequent measurements.

1.2.6 D.C. Output

The Model 92B provides a linear d.c. output whose current capability of 1 mA into 1000 ohms is extremely stable. When used as part of an automatic test system, the fast response of the instrument's d.c. output to an input step-function allows many tests per unit time.

For system or external requirements, all input and output connections for the Model 92B are made at the card-edge connector at the rear of the instrument. (See Figure 10 for receptacle connections.)

CHAPTER II

SPECIFICATIONS

Voltage Range: 200 µV to 3 V (300 V up to 700 MHz with accessory 100:1 voltage divider). Lowest detectable voltage is approximately 100 µV.

Full-Scale Voltage Range: 1, 3, 10, 100, 300, 100, and 3000 mV.

dBm Range: -60 to +23 dBm (+63 dBm up to 700 MHz with optional accessory, 100:1 Voltage Divider).

Frequency Range: 10 kHz to 1.2 GHz (uncalibrated response to approximately 8 GHz).

Accuracy:

	1% f.s., plus			
300 mV to 3 V	1% rdg.	1% rdg.	3% rdg.	10% rdg.
200 µV* to 300 mV	2% rdg.			7% rdg.
	10 kHz	50 kHz	150 MHz	700 MHz 1.2 GHz

*Below 1 mV, add 1% f.s.

Meter: 4½-inch taut-band

Two linear voltage scales:

0 to 3; 0.05 per division

0 to 10; 0.1 per division

One logarithmic dBm scale:

-10 to +3; 0.2 per division, max.

Meter Unrest:
(1 mV f.s. range, only)

Indicated Voltage	Unrest
Above 600 µV	< 1% f.s.
300 µV to 600 µV	< 2% f.s.
200 µV to 300 µV	< 5% f.s.

Power: 115 or 230 V ± 10%, 50 to 400 Hz.

R.F.I.: There is no detectable radiated or conducted leakage from the instrument or the probe.

Temperature: In accordance with ANSI (ASA) Spec. 39.7

Temperature Range	Temperature Influence	
	Instrument	R.F. Probe
Ref. 21°C to 25°C	0	0
Normal, 18°C to 30°C	0	± 1% rdg.
Severe, 10°C to 40°C	± 1% rdg.	± 4% rdg.

Waveform Response: True r.m.s. response for input levels up to 30 mV (3 V to 700 MHz with 100:1 Voltage Divider), with transition to peak-to-peak (calibrated in r.m.s.) at higher levels.

Crest Factor: 420 to 1.4, depending upon input level (see Table II).

Input Impedance: See Figures 1 and 2.

S.W.R.: Less than 1.20, to 1.2 GHz (Return Loss greater than 23 dB). See Figures 3 and 4.

Power Sensitivity: 800 pW, minimum measurable power in 50 ohms. (Minimum detectable power in 50 ohms is 200 pW.)

D.C. Output: 0 to 10 V, d.c., proportional to r.f. input voltage. Source resistance of 9 kΩ; will deliver 9 mA into 1-kΩ load. Full-scale input step-function response time less than 100 ms on 30-mV, f.s., to 3-V, f.s., ranges, increasing to 1 s on the 1-mV, f.s., range.

Warm-up: Warm-up period typically 1 min. Adjust ZERO on 1-mV range when measuring below 30 mV.

Dimensions: 132 mm high (without rubber feet) × 211 wide × 292 deep (5.2 in. × 8.3 × 11.5).

Weight: Net 3.2 kg (7 lbs).

Accessories Furnished:

Model 91-12F, R.F. Probe. R.F. probe with low-noise cable and connector assembly for measurements from 10 kHz to 1.2 GHz; see Figures 1 and 2 for input resistance and capacitance.

Model 91-13B, Probe Tip. Removable probe tip with grounding-clip lead; for use up to approximately 100 MHz.

Model 91-8B 50 Ohm BNC Adapter. Used for measurements up to 600 MHz with a 50 ohm system; for s.w.r., see curve of Figure 3.

Accessory Kit (Optional)

Model 91-6C, Unterminated BNC Adapter. Used for coaxial connection up to approximately 100 MHz, or to 400 MHz when fed from a 50 ohm source in an electrically short system.

Model 91-7C, 100:1 Voltage Divider. Attenuates input signal by a factor of $100 \pm (1 + f_{MHz}/200)\%$, permitting measurements up to 300 volts and extending the r.m.s. measuring range to 3 volts; increases input resistance by a factor of 1000 to 3000, depending upon input level; operates from 50 kHz to 700 MHz. Maximum input potential, 1000 volts, d.c. plus peak a.c.

Model 91-14A, 50 Ohm Tee Adapter. Type-N Tee connector; with Model 91-15A termination (see below) permits connection into 50 ohm line; required for measurements above approximately 100 MHz; for s.w.r., see curve of Figure 4.

Model 91-15A, 50 Ohm Termination. Type-N 50 ohm termination for use with Tee Connector.

Model 91-18B Storage Case. Case for protecting and storing Model 92B accessories.

Other Accessories Available (Optional):

Model 91-4C, Special 1 kHz to 250 MHz R.F. Probe. Low-frequency probe for measurements ranging from 1 kHz to 250 MHz; input resistance is essentially the same as that of the Model 91-12F Probe.

Model 91-16A, Unterminated Type-N Adapter. May be used with all probes, except Model 91-23A. Used for coaxial connection up to approximately 100 MHz, or to 400 MHz when fed from a 50 ohm source in an electrically short system.

Optional Accessories Available (Continued)

Model 950032, Single Rack-Mounting Kit. Kit for mounting one 92B as one-half of a module in a standard 19-inch rack.

Model 950030, Double Rack-Mounting Kit. Kit for mounting two 92B's side-by-side in a standard 19-inch rack.

Model 92B-04, dBV option; dB scale, referred to 1 volt, is read out of top scale on meter.

Model 92B-06, 75 Ω dBm option; dBm scale, referred to 75 Ω, read out on top scale on meter.

Model 92B-08. Rear signal-input option.

Model 92B-12, dBmV option; dB scale, referred to 1 mV.

NOTE: To exploit fully the capabilities of this instrument, the accessories listed below are required for the indicated ranges of operation

Table 1. Required Accessories

MEASURING RANGE	REQUIRED ACCESSORY	REMARKS
100 MHz to 600 MHz	50 ohm adapter for shielded connection to 50 ohm line; other impedances available on request.	Supplied as standard equipment.
Above 600 MHz	Tee Connector and 50 ohm Termination for connection into 50 ohm line.	Available separately
1 kHz to 250 kHz	Low-Frequency R.F. Probe	Available Separately
Input levels up to 300 V; r.m.s. response with levels to 3 V.	100:1 Voltage Divider; operates over frequency range from 50 kHz to 700 MHz.	Available separately

Table 2. Crest Factors

VOLTAGE RANGES (mV) AND CREST FACTORS								
VOLTAGE RANGES (mV)	1	3	10	30	100*	300*	1000*	3000*
CREST FACTOR**	420 to 42	70 to 14	21 to 4.2	7 to 1.4	420 to 42	70 to 14	21 to 4.2	7 to 1.4

*With accessory 100:1 Voltage Divider (see Table 1).

**Maximum permissible ratio of peak-to-r.m.s value of voltage.

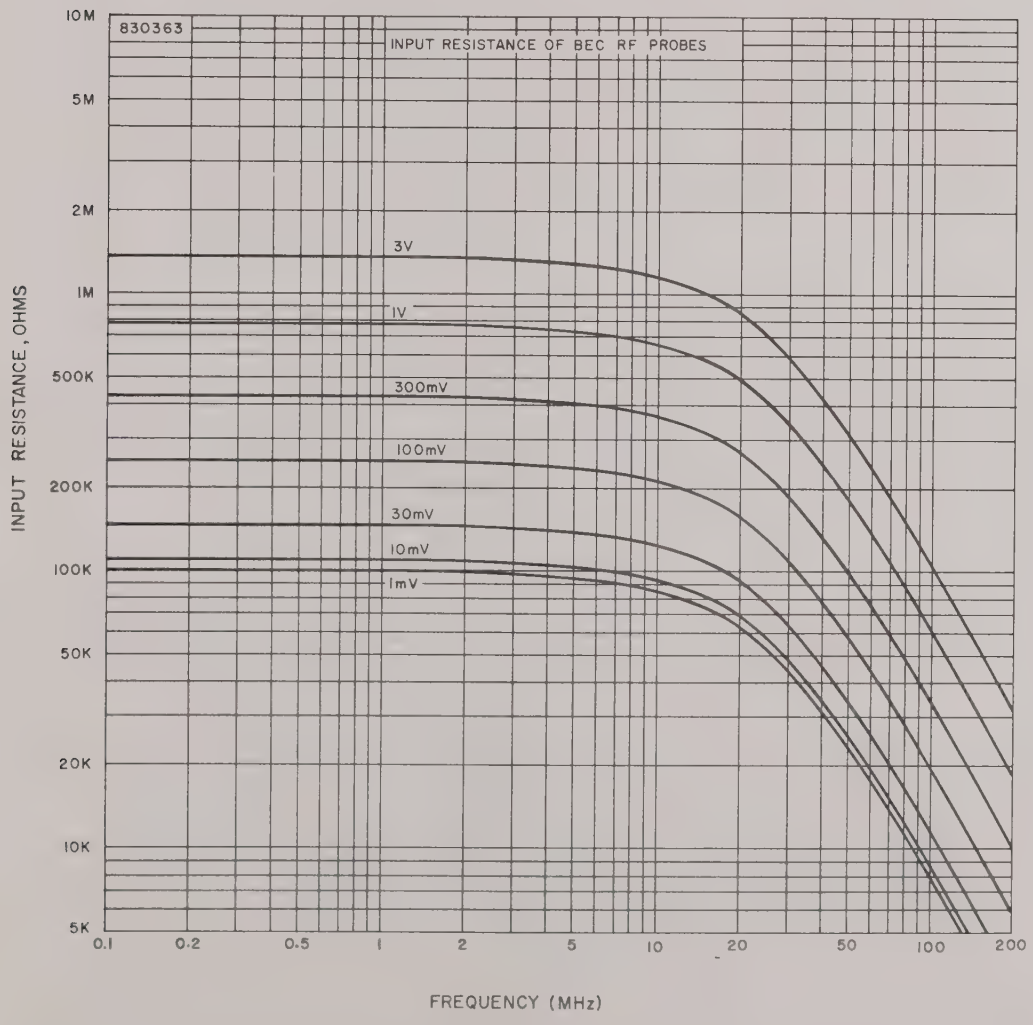


Figure 1. Input Resistance of R.F. Probe as a Function of Input Level and Frequency

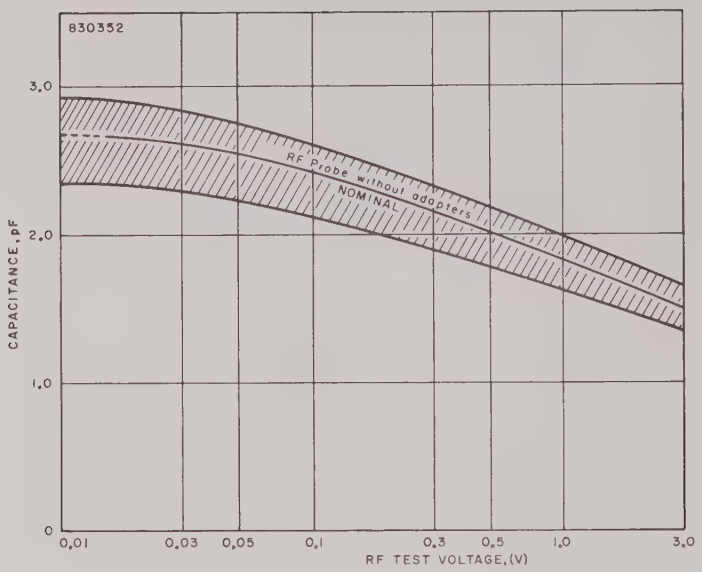


Figure 2. Input Capacitance vs. Input Level of Probe (Measured at 10 MHz)

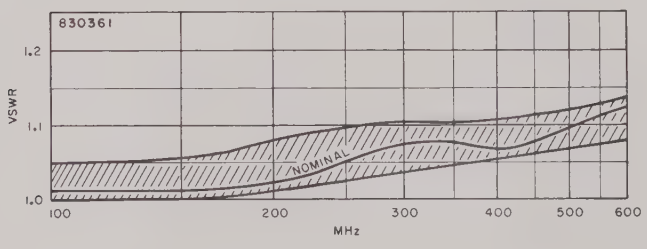


Figure 3. Typical S.W.R. of R.F. Probe with 50 Ω Adapter

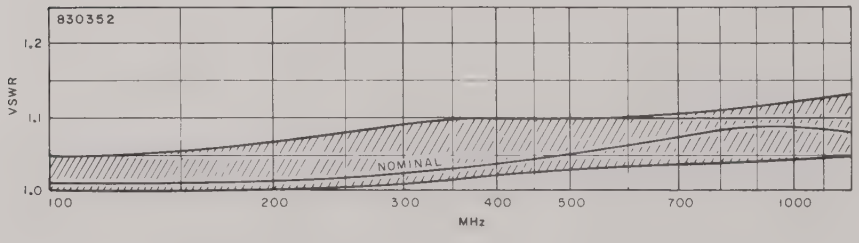


Figure 4. Typical S.W.R. of R.F. Probe with Type-N Tee Adapter and 50 Ω Termination

CHAPTER III

OPERATION

3.1 INSTALLATION

The Model 92B has been inspected and tested at the factory before packing, and it is shipped ready for operation. If there is any indication of shipping damage, immediately notify the carrier before attempting to put the instrument into operation.

3.1.1 Operating Controls and Indicators

The controls and indicators are shown in Table 3.

Table 3. Model 92B Controls and Indicators

PWR ON	This switch turns on the instrument power.
FULL SCALE	These range pushbuttons (1, 3, 10, 30, 100, 300, 1000, and 3000 mV, and -50, -40, -30, -20, -10, 0, +10, and +20 dB) select the operating range.
Meter	A 4-1/2 inch taut-band meter with two linear voltage scales reading-out to 3, with 0.05 per division, and to 0, with 0.1 per division; and one logarithmic dBm scale, reading-out to -10 to +3 with 0.2 per division, max.
PROBE (Jack)	The probe cable connects to the instrument through this PROBE jack. Always check that the knurled ferrule nut of the probe-cable connection is tightened when in use
ZERO (Control)	This control is used to "zero" the instrument.

The following items are on the rear panel:

Fuse Holder and Fuse	A fuse holder is located on the rear panel for installing either a 0.10 A, 115 V, or a 0.06 A, 220 V, Bussman MDL SLO-BLO fuse.
Slide Switch	Switch that is set to 115 or 230 V, according to the available power source. Be sure that the proper fuse is located in the fuse holder.

Recorder Output Terminals (Rear Panel)	A d.c. voltage proportional to the indicator reading is available at these terminals. F.S. Output = +10 V Output Resistance = 9 kΩ
Component Holders (Clips)	Three component holders, or component clips, are located at the rear panel for securing accessories that are not in use.
REMOTE CONNECTIONS	A card-edge connector is mounted at the rear of the instrument. See Figure 11 for the pin designations. (Use with an Amphenol 225-22221-103 connector, or equivalent.)
(Symbol on Rear Panel) 	This safety requirement symbol has been adopted by the International Electrotechnical Comission, Document 66 (Central Office) 3, Paragraph 5.3, which directs that an instrument be so labeled if, for the correct use of the instrument, it is necessary to refer to the instruction manual. In this case it is recommended that reference be made to the instruction manual when connecting the instrument to the proper power source. Verify that the correct fuse is installed for the power available and that the switch on the rear panel, "0.01 A and 0.06 A, 50-400 Hz", is set to the applicable operating voltage of 115 V or 230 V.

3.2 OPERATING PROCEDURE

In the following paragraphs the initial operating procedure is described, as well as operating notes and recommended connection methods.

3.2.1 Initial Operating Procedure

a. Be sure that the serial number of the probe to be used is the same as that of the voltmeter. (Each instrument is calibrated for its particular r.f. probe.) Use of a probe other than that for which the instrument was calibrated may result in measurement errors.

b. Connect the probe cable to the PROBE jack on the front panel.

c. Check the setting of the power switch on the rear panel to be sure that it is set to the proper position for the line voltage available.

d. Plug the instrument's power cable into a power receptacle. Push PWR ON switch button.

e. Press the 1 mV range button; the panel-meter pointer should rest on zero. If it does not, use the ZERO control to set the meter to zero. (This adjustment will hold for the other ranges.) The instrument is now ready for use. (See Paragraph 3.3.5.)

3.3 OPERATING NOTES

While using the Model 92B is a direct and straight-forward process, there are certain precautions and procedures which MUST be observed to obtain satisfactory results.

3.3.1 Overload Limits

The 91-12F R.F. Probe supplied with the instrument is overload-protected to 10 V, a.c., and to 400 volts, d.c. EXCEEDING THESE LIMITS MAY RESULT IN PERMANENT DAMAGE TO THE PROBE.

The 92-8B 50 ohm adapter should not be subjected to continuous overload of more than 10 volts [d.c. + (a.c., r.m.s.)], to avoid excessive heating of the terminating resistor.

Where voltages above these limits are likely to be encountered, the 91-7C 100:1 Voltage Divider is required. Maximum rating of the Voltage Divider is 1000 volts, d.c. + peak a.c.

3.3.2 Connection for Measurements below 100 MHz

The R.F. Probe supplied with the 92B is equipped with a detachable tip and ground lead. For measurements of signals below approximately 100 MHz, this tip provides a convenient means for both signal and ground connection.

3.3.3 Connection for Measurements above 100 MHz

For frequencies above 100 MHz, the probe tip should NOT be used with the Model 92B. Connection should be made directly to the probe's center contact, with the ground connection kept as short as possible.

The connection recommendations outlined in Table 4 should be followed to maintain specified accuracy.

Table 4. Connection Recommendations

FREQUENCY	SIGNAL CONNECTION
Up to 100 MHz	Probe with tip and ground lead, or with 91-8B (supplied). Probe with Model 91-14A/15A (optional).
100 to 250 MHz	Probe without tip, or probe with 91-8B (supplied). Probe with Model 91-14A/15A (optional).
250 to 600 MHz	Probe with Model 91-8B (supplied). Probe with Model 91-14A/15A (optional).
600 MHz to 1.2 GHz	Probe with 91-14A/15A (optional). See Figure 5.

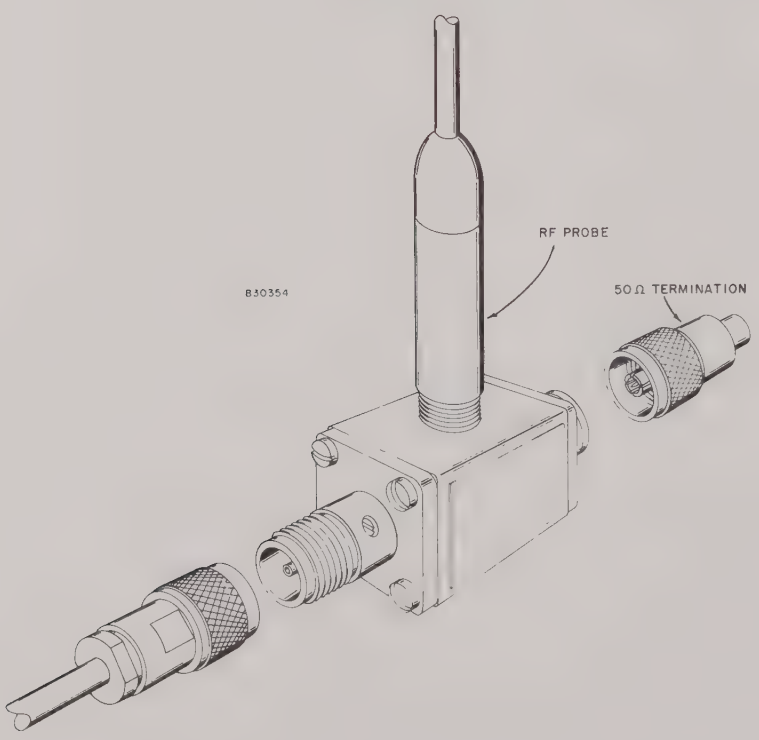


Figure 5. Assembly of Type-N Tee Adapter

3.3.4 Low-Level Measurement

The voltmeter will provide reliable, reproducible measurements of signal levels as low as 200 microvolts.

Preliminary zero adjustment is essential when using the lowest-range scale to achieve the specified accuracy, and it is strongly recommended for all ranges up to 30 mV.

3.3.5 Making the Zero Adjustment

When the instrument is to be used on the 1 mV range, the following zero adjustment procedure should be followed.

a. Set the FULL SCALE range selector to the 1 mV position.

b. Be sure that no voltage is applied to the probe, and that it is adequately shielded from local fields. This can be done by partially unscrewing the probe cap until the tip just breaks contact with the internal connector, leaving the metal shell engaged with the body threads. Alternately, the probe tip can be removed and the 50 ohm termination (Model 91-8B) mounted in its place.

c. Adjust the ZERO control to bring the meter reading to zero. Noise will cause the reading to fluctuate up to ±5% of full scale. Adjust the ZERO control so that the reading averages zero.

3.3.6 Signal Overload on 1 mV Range

On the most sensitive (1 mV) range, application of a large a.c. signal overloads the amplifier and a short time is required for the high-impedance input circuit to discharge. This effect is significant for signals above approximately 100 millivolts. Typically, application of a 1 volt signal will require a recovery time of about thirty seconds before subsequent measurements should be made. It should be noted, however, that such overloads cause no damage to the equipment as long as they are within the limits outlined in Paragraph 3.3.1.

3.3.7 Temperature Effects

The accuracy specifications for the 92B apply over temperatures from 50°F to 104°F. Outside of these limits operation of the equipment is possible but appreciable inaccuracies can be expected. However, no permanent change in probe characteristics will result from any reasonable high or low temperature exposure.

It should be noted that inaccuracies of measurement resulting from temperature effects may

occur shortly after soldering to the probe tip, or measuring with the probe in the vicinity of heat sources such as resistors, heat sinks, vacuum tubes, and so forth

When making low-level measurements (below approximately 2 millivolts) it is important to make sure that the probe has attained a uniform temperature throughout its body. A temperature gradient between the inside and the outside of the probe can generate a small thermal voltage that may add to the d.c. output of the detector diodes.

3.3.8 Hum, Noise and Spurious Pick-up

When measuring low-level signals, precautions should always be taken to avoid the possibility of errors of measurment resulting from hum, noise or stray r.f. pick-up. Although all low-frequency hum and noise are attenuated at the input, it is still possible for unwanted high-level signals to cause errors. In some cases it may be necessary to provide extra shielding around the probe connections to reduce stray pick-up. Typical sources of spurious radiation are: induction or dielectric heating units, diathermy machines, local radio transmitters, and grid dip meters.

3.4 D.C. OUTPUT

The d.c. output provided at the rear-panel binding posts is a linear function (typically within 1%) of the input level, as long as the input signal is greater than 20% of full scale. The polarity of the d.c. output is positive with respect to the instrument ground, the negative d.c. output terminal being at ground potential. The output resistance is 9 kΩ.

3.5 LOW-FREQUENCY MEASUREMENTS

The 91-12F R.F. Probe supplied with the 92B provides measurements within the specified accuracy from 10 kHz to 1.2 GHz. For measurements at lower frequencies the Model 91-4C R.F. Probe is available. It operates over a frequency range from 1 kHz to 250 MHz.

IMPORTANT NOTE

After installing the 91-4C R.F. Probe, the Model 92B MUST BE checked for accuracy of calibration. The voltmeter must be recalibrated, if required. (See Paragraphs 5.3 and 5.4.)

3.6 CORRECTION CURVE FOR MODEL 91-8B, 50 Ω BNC ADAPTER

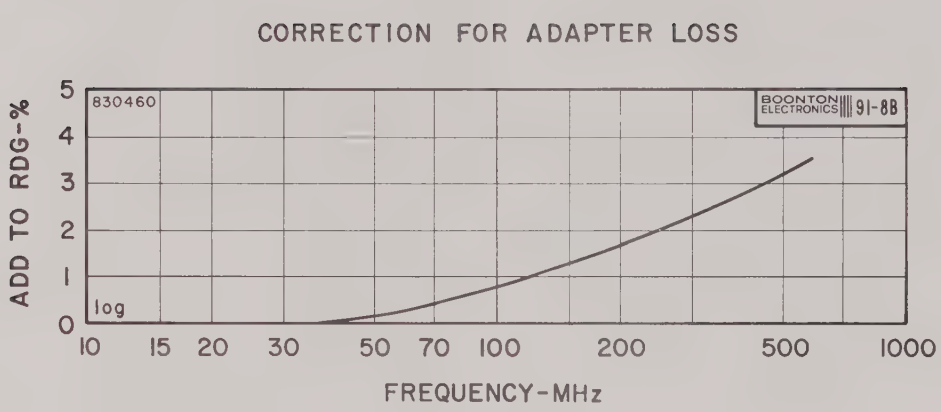
When using the Model 91-8B, 50 ohm adapter, at frequencies between 50 and 600 MHz, increase the measured voltage by the percentage shown in Figure 6A.

3.7 CORRECTION CURVE FOR MODEL 91-14A, 50 Ω TEE ADAPTER

Use the curve of Figure 6B to make currections for transmission loss when using the Type N Tee Adapter.

The meter reads the voltage applied to the input port of the Model 91-14A Adapter. The loss in dB between input and output ports is given in Figure 6B. Subtract the correction from the meter's indicated value, in dB, to obtain the output voltage of the tee.

Example: At 850 MHz, the output level is 1 dB less than the input level, which is indicated on the meter.



EXAMPLE:
AT 250MHz, METER READS 50mV.
ADD 2%. TRUE VOLTAGE IS 51mV.

Figure 6A. Model 91-8B 50 Ω BNC Adapter Correction Curve

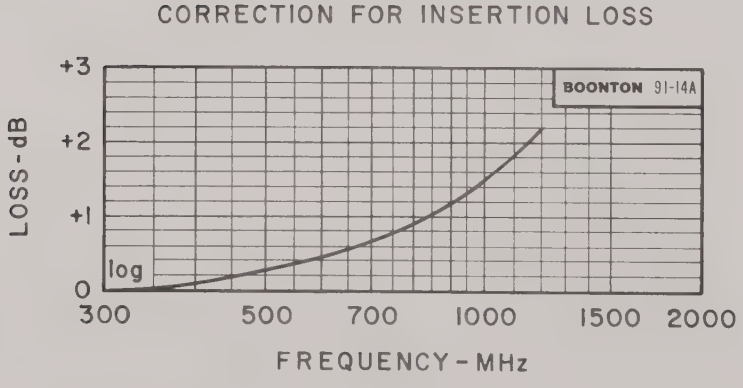


Figure 6B. Model 91-14A Type-N Tee Adapter Correction Curve

CHAPTER IV

THEORY OF OPERATION

4.1 GENERAL

The operating principles of the Model 92B are shown in the following block diagram (Figure 7). The essential elements of the instrument are the probe, chopper driver, chopper, attenuator, amplifier, pulse generator, sync detector, shaping amplifier, panel meter, and power supply.

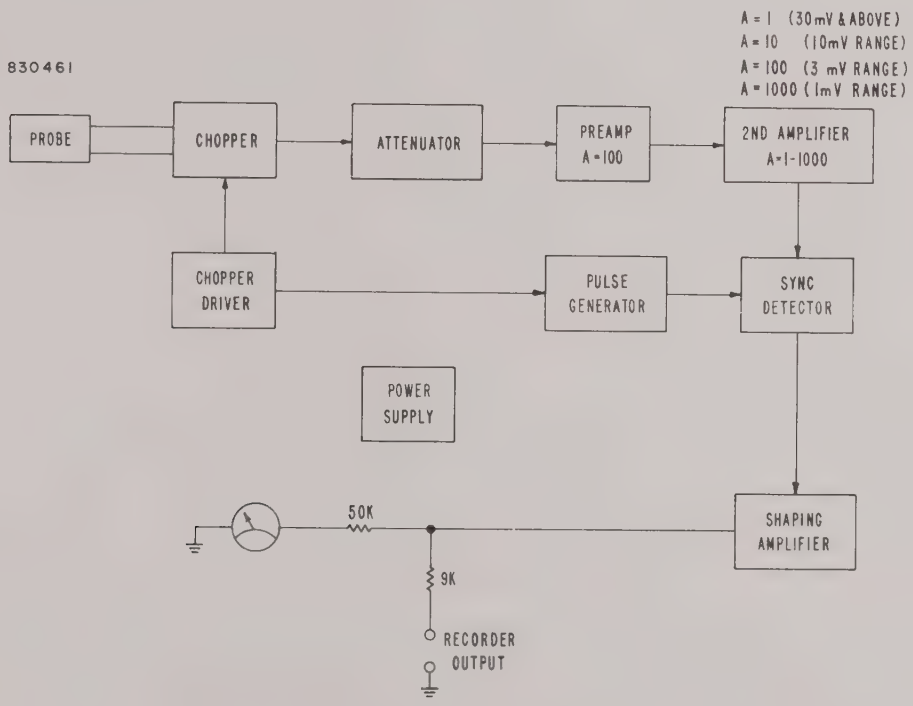


Figure 7. Block Diagram

4.1.1 R.F. Probe

The R.F. probe embodies a full-wave diode detector that rectifies the signal under study to a d.c. voltage whose level is a function of the input level. While operating in the square-law region (below approximately 30 millivolts), the detector provides a true r.m.s. response. As the input level increase beyond 30 millivolts, waveform response gradually approaches peak-to-peak, calibrated on the scale in r.m.s.

In addition to increasing efficiency, use of full-wave rectification in the detector probe permits measurement of signals having highly asymmetrical waveforms without errors stemming from turnover effect.

The diodes used in the R.F. Probe have been carefully selected for specific characteristics. The user is urged NOT to attempt their replacement with any off-the-shelf types. In case of damage to probe components, call your local Boonton Electronics Sales Engineering Representative or the factory for instructions.

4.1.2 Attenuator and Amplifiers

The d.c. output of the probe is converted to a.c. by the mechanical chopper. The resultant a.c. signal is applied to the attenuator and amplifier sections. For each range the output voltage from the second amplifier is approximately 3 V, peak-to-peak. It is accomplished by ranging both the attenuation and the gain of the second amplifier in the following manner:

RANGE	1 ATTN.	GAIN 2nd AMP.
1	1	1000
3	1	100
10	1	10
30	1	1
100	0.15	1
300	0.04	1
1000	0.01	1
3000	0.004	1

The preamplifier has a constant gain of ×100, and is designed for very low input noise. Both amplifiers have moderately wide bandwidths and are stabilized by large amounts of negative feedback.

4.1.3 Synchronous Detector

The amplified a.c. signal from the second amplifier is converted to d.c. by the synchronous detector. The peak-to-peak amplitude is derived from a shunt-series capacitor storage circuit using JFET switches. The synchronous detector is driven by pulses in the chopper-driver circuit, thus assuring exact synchronization. The characteristics of the detector determine the effective bandwidth of the amplifier-detector combination and allow modification of the bandwidth for different range conditions. The detector also provides conversion without offset, with excellent linearity.

4.1.4 Shaping Amplifier

The conversion of r.f. to d.c. in the probe is non-linear, the response being virtually square law for the lowest ranges and gradually becoming quasi-linear for the 3 V range. The shaping amplifier converts the non-linear output of the phase detector to a linear output by using a segmental approximation to the exact correction. The shaping amplifier is actually an operational amplifier so connected that, as the signal increases at its output, its gain is reduced by successively paralleling resistors across the feedback resistors. The number of segments required to adequately linearize the response varies from 6 for the "square-law" ranges down to 2 for the 3 V range. The output of the shaping amplifier is +10 V, which drives the panel meter and is applied to the recorder terminals through a 9 kΩ resistor.

4.1.5 Chopper-Driver Circuits

The chopper-driver block provides all of the drive signals required by the instrument. The chopper frequency is obtained by dividing the output of a unijunction oscillator by two. The oscillator also generates the switching pulse for the synchronous detector. Diode gating feeds the pulse to the proper JFET depending upon chopper phase. The chopper frequency is normally adjusted to 94 Hz, but can be changed as much as ± 10 Hz to avoid beating with harmonically related ground signals.

4.1.6 Power Supply

The power supply converts the a.c. input power to regulated +15 V and -15V outputs. Each supply is protected by current limiting against accidental short circuits. Both supplies are adjustable to 15.0 ± 0.1 V.

4.1.7 Programming

The instrument is organized around an eight-line ranging system. In each functional sub-circuit the switching is accomplished by solid-state devices, generally JFET's, which are actuated by the appropriate range line. The front-panel range switch simply connects to the eight range lines to allow range selection. The range lines are buffered by a logic-level converter. The instrument can be externally ranged by a logic "0" command on the appropriate range line and manual disable line. (It is recommended that an Amphenol connector, or equivalent, be used for remote programming connection.)

CHAPTER V

MAINTENANCE

NOTE: The values and tolerances shown in this section are not specifications but are provided only as guides to the maintenance and calibration of this instrument.

5.1 PERIODIC CALIBRATION

The Model 92B is designed to provide trouble-free operation over extended periods of time. However, as with any precision instrument, the instrument should be check periodically to verify proper calibration. To make such calibration checks, the following equipment is required:

a. A reliable signal source of 200 kHz to 500 kHz with less than 1% distortion at levesl up to 3 volts across 50 ohms.

b. A precision voltmeter such as the Ballantine 310A or 300H, the Boonton Electronics Model 93A or 93AD, or the Hewlett-Packard Model 400D or 400H, or equivalent.

NOTE: A Boonton Model 26A R.F. Millivoltmeter Calibrator can be substituted for Items a. and b. above. This calibrator provides 1 MHz voltages from 60 µV to 3 V with an uncertainty of < ± 0.5% of indication. Full-scale voltages in a 1-3-10 sequence can be switch-selected. On any range incremental voltages can also be selected in 10% f.s. steps.

c. A precision d.c. voltmeter capable of measuring ± 15.0 V with an accuracy of 0.25%.

d. A frequency counter, such as the Monsanto Model 100A.

5.2 PRECAUTIONS WHEN CHECKING CALIBRATION

When checking the calibration of an instrument having the sensitivity and bandwidth of the Model 92B, it is essential to take precautions agains errors resulting from stray pick-up voltages. (See Paragraph 3.3.8.) A well shielded signal source must be used in conjunction with coaxial connections to both the Model 92B and the standard reference meter. Even with a well shielded generator and connections, it is sometimes possible for the reference meter to pick up stray r.f. signals and feed them into the probe. It is advisable to test for this condition by disconnecting the standard meter and noting any change in level.

5.3 CALIBRATION CHECK

Using the equipement listed in Paragraph 5.1, check the calibration of the Model 92B on each range using a test voltage equal to the full-scale value. If the check reveals that recalibration is required, the procedure outlined in Paragraph 5.4 should be followed.

5.4 CALIBRATION PROCEDURE

The Model 92B should be calibrated at room temperature (74°F) after a minimum warm-up time of five minutes.

A calibration outline is provided inside the top cover of the instrument (see Figure 8). The adjustment reference listed below are the same as those recorded on the top cover.

Adjustment No. 1. Measure the -15.0 supply voltage at the -15 V Test Point located on the Main Amplifier board at C119. Adjust R143 for a reading of -15.0 ± 0.1 V.

Adjustment No. 2. Measure the +15.0 V supply voltage at the +15 V Test Point located on the Main Amplifier board at C118. Adjust R140 for a reading of +15.0 V ± 0.1 V.

Adjustment No. 3. Set the FULL SCALE range selector to the 1000 mV range, apply 1000 mV input and measure the chopper frequency at Test Point 13, located on the Chopper-Driver board. Adjust R244 for a frequency of 94 ± 1 Hz (106.4 ms). In some cases it may be desirable to offset the chopper frequency to avoid beating with a harmonic of the power-line frequency. Any frequency within the adjustment range will not degrade the performance of the instrument.

Adjustment No. 4. Set the FULL SCALE range selector to the 1 mV range and zero the instrument as described in Paragraph 3.3.5.

Adjustment No. 5. Set the FULL SCALE range selector to the 30 mV range and adjust R233 for a zero reading of the RECORDER terminals on the back panel.

Adjustment No. 6. Set the FULL SCALE range selector to the 1000 mV range and apply 1000 mV input; adjust R353 for +10.00 V at the RECORDER terminals.

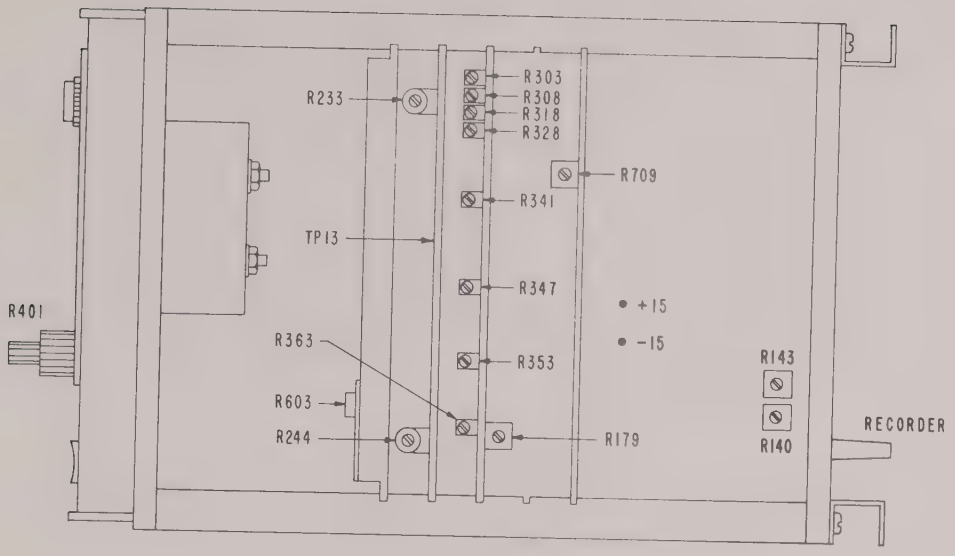
Adjustment No. 7. Set the FULL SCALE range selector to the 1000 mV range and apply 1000 mV input; adjust R179 for a 1000 mV indication.

Adjustment No. 8. Set the FULL SCALE range selector to the 3000 mV range and apply 3000 mV input; adjust R363 for a 3000 mV indication.

Adjustment No. 9. Set the FULL SCALE range selector to the 1 mV range (zero the instrument as in Adjustment No. 4), apply 1.000 mV input, and adjust R303 for a reading of 1.000 mV.

Adjustment No. 10. Set the FULL SCALE range selector to the 3 mV range (zero as in Adjustment No. 4), apply 10.00 mV, and adjust R308 for a reading of 10.00 mV.

Adjustment No. 11. Set the FULL SCALE range selector to the 10 mV range (zero as in Adjustment No. 4), apply 10.00 mV, and adjust R318 for a reading of 10.00 mV.



• TEST POINT
† REPEAT STEP #4
⊛ FACTORY ADJUSTMENT: REFER TO MANUAL
ADJ 15-16 ON 92B8 ONLY

ADJ NO	CONT	FUNCTION	RANGE	INPUT ±0.2%	ADJUST
1	R143	-15 V ADJ	—	0	-15.0V ±0.1V AT -15V TP
2	R140	+15 V ADJ	—	0	+15.0V ±0.1V AT +15V TP
3	R244	CHOPPER FREQUENCY	1000 mV	1000 mV	94±1Hz AT TP 13
4	R401	FRONT PANEL ZERO	1 mV	0	AVERAGE ZERO INDICATION
5	R233	DC ZERO	30 mV	0	ZERO INDICATION
6	R353	RANGE ADJ	1000 mV	1000 mV	+10.00V AT RECORDER TERMINALS DC VOLTMETER INPUT > 10 M OHMS
7	R179	METER FS ADJ	1000 mV	1000 mV	1000 mV INDICATION
8	R363	RANGE ADJ	3000 mV	3000 mV	3000 mV INDICATION
9 †	R303	RANGE ADJ	1 mV	1 mV	1.000 mV INDICATION
10 †	R308	RANGE ADJ	3 mV	3 mV	3.000 mV INDICATION
11 †	R318	RANGE ADJ	10 mV	10 mV	10.00 mV INDICATION
12	R328	RANGE ADJ	30 mV	30 mV	30.00 mV INDICATION
13	R341	RANGE ADJ	100 mV	100 mV	100.0 mV INDICATION
14	R347	RANGE ADJ	300 mV	300 mV	300.0 mV INDICATION
15	R603	CHARGING VOLTAGE ADJ	—	—	7.00V ACROSS OPEN BATTERY LEADS
16	R709	LOW VOLTAGE CUT OUT ADJ	—	—	INSTRUMENT TURN OFF AT 6.00V ⊛

Figure 8. Calibration Instructions

Adjustment No. 12. Set the FULL SCALE range selector to the 30 mV range, apply 30.00 mV input, and adjust R328 for a reading of 30.00 mV.

Adjustment No. 13. Set the FULL SCALE range selector to the 100 mV range, apply 100.0 mV input, and adjust R341 for a reading of 100.0 mV.

Adjustment No. 14. Set the FULL SCALE range selector to the 300 mV range, apply 300.0 mV input, and adjust R347 for an indication of 300.0 mV.

5.5 TROUBLESHOOTING PROCEDURE

The following troubleshooting procedures describe the instrument's cover removal, chopper replacement, and voltage and resistance tests.

5.5.1 Cover Removal

The instrument's cover is removed from the case by removing the screw on top of the case.

5.5.2 Chopper Replacement

If unsatisfactory operation develops, a replacement chopper should be tried. (NOTE: The chopper used in the Model 92B is a special Boonton Electronics Corporation part. For replacements or spares, call your local Boonton Electronics Representative, or the factory.) If the new chopper does not clear the difficulty, place the original chopper back in the socket. The calibration accuracy should be rechecked after replacement.

5.5.3 Voltage and Resistance Tests

After determining that the trouble cannot be cured by replacement of the chopper (as noted above), it is advisable to make a systematic check of the a.c. voltage, d.c. voltage, and resistance. Once the trouble has been found and corrected, the calibration must be rechecked and readjusted as outlined in Paragraphs 5.3 and 5.4.

5.5.4 Test Points

Test points, waveforms, and related test-voltages are shown in the schematics.

5.5.5 Replacement of R.F. Probes

The serial number of the instrument matches that of the R.F. Probe with which it was calibrated at the factory. If it is necessary to change probes for any reason, the instrument's calibration MUST be rechecked. In most cases, full recalibration (see Paragraph 5.4) will be

required. Similarly, if the R.F. Probe supplied with the instrument is exchanged for a Low-Frequency Probe, recalibration will be required. (See Paragraph 3.5.)

5.5.6 Probe Tests

The probe assemblies furnished with the Model 92B can be checked for s.w.r. and frequency response by following the procedures detailed in the paragraphs below.

Should a probe exhibit out-of-tolerance performance in these tests, the user is urged not to attempt repair himself but to send it back to the factory for repair or replacement.

A. S.W.R. Measurement

1. Test Equipment

a. Generator for the desired frequency range. Suggested signal sources are:
125 kHz - 175 MHz, Boonton Electronics Model 103C, or 103D
450 kHz - 520 MHz, Boonton Electronics Model 102E, or 102F
10 MHz - 1400 MHz, Hewlett-Packard Model 8660 A/C

b. Slotted line: GR Type 900 LB

c. Detector: GR Type 1241, or Boonton R.F. Millivoltmeter 92B or 92C.

2. Test Procedure

a. Connect the slotted line to a proper signal source, and terminate the line with the device to be tested, i.e., Boonton Model 91-14A Tee Adapter and Boonton Model 91-15A 50 Ω Termination, or Boonton Model 91-8B 50 Ω Adapter.

It is necessary that the probe and R.F. Millivoltmeter be connected to whichever accessory is being tested. The probe supplies a perturbation for which the accessory was designed, and which it needs, to meet its specification, and the millivoltmeter permits the test level to be set to the desired value.

b. Move the carriage of the slotted line to a point of minimum voltage, then to a point of maximum voltage, and record the values.

c. The s.w.r. is the ratio of the maximum and minimum voltages. The measurement can be repeated at other frequencies and levels, as required.

B. Frequency Response

The most accurate method of measuring the frequency response of the R.F. Probe for the R.F. Millivoltmeter is through the use of micropotentiometers, electrothermic a.c.- d.c. transfer instruments and A-T (attenuator-thermoelement) voltmeters. Users who have these instruments available will be familiar with their application.

A method of suitable accuracy, compatible with the accuracy of the 92B, uses a point-by-point frequency scan in conjunction with a power divider and calibrated power meter. The method is detailed in the following paragraphs.

1. Test Equipment

a. Signal source for the frequency range of 10 to 1200 MHz. Suggested instruments are Wavetek 2001 or H-P 8660 A/C. In this application, the generator is manually swept.

b. Power Splitter: Weinschel Model 1870A, or H-P 11667A.

c. Calibrated R.F. Power Meter: Boonton Model 42B/BD, or H-P Model 435A.

2. Test Procedure

a. Connect the equipment as shown in Figure 9.

b. Set the frequency of the generator to 10 MHz, and adjust the output control for the desired test level. If the response is to be measured at one level only, a test voltage of 100 or 200 mV is recommended.

c. Disable the output of the generator momentarily and zero the power meter. Re-establish the output level and note the reading on the power meter. Record the frequency of the generator and the reading of the 92B R.F. Millivoltmeter. Change the frequency, in whatever increments are desired, through the range of 10 to 1200 MHz, holding the reference reading on the power meter constant.

d. Reverse the output ports of the power divider and repeat Step (c).

e. The correct voltmeter reading is obtained at each frequency by averaging the two readings. This virtually eliminates the influence of frequency differences of the two ports of the power divider.

f. Further refinements can be made by filtering the output of the generator, and measuring the complex reflection coefficients of the power meter, r.f. millivoltmeter accessory

under test, and all ports of the power divider. The ususal corrections can then be made. These procedures are not usually necessary, and should be done only if the additional accuracy is warranted.

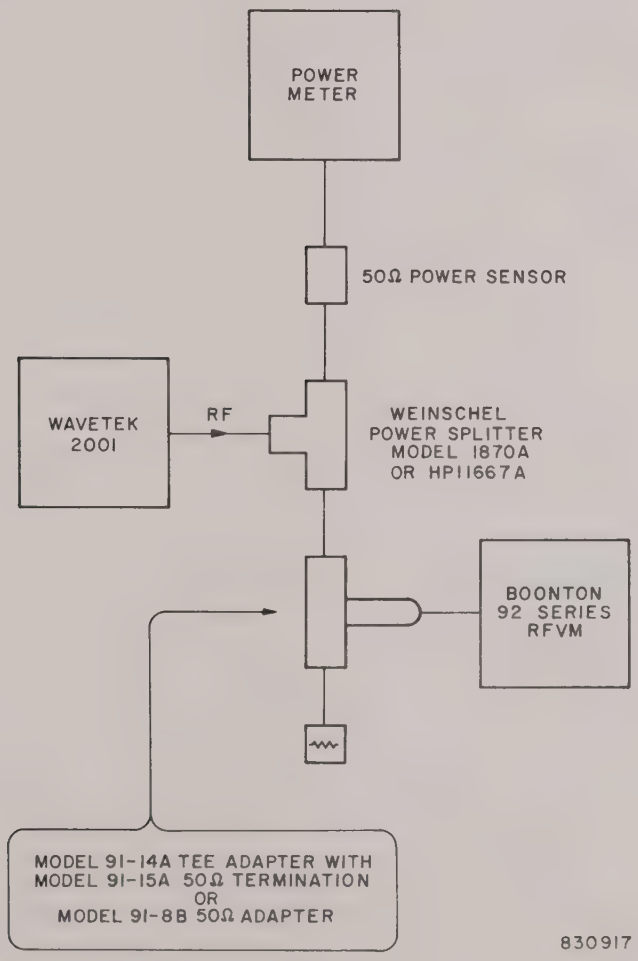

POWER METER
50Ω POWER SENSOR
WAVETEK 2001
RF
WEINSCHEL POWER SPLITTER MODEL 1870A OR HP11667A
BOONTON 92 SERIES RFVM
MODEL 91-14A TEE ADAPTER WITH MODEL 91-15A 50Ω TERMINATION OR MODEL 91-8B 50Ω ADAPTER
830917

Figure 9. Frequency-Response Test Setup

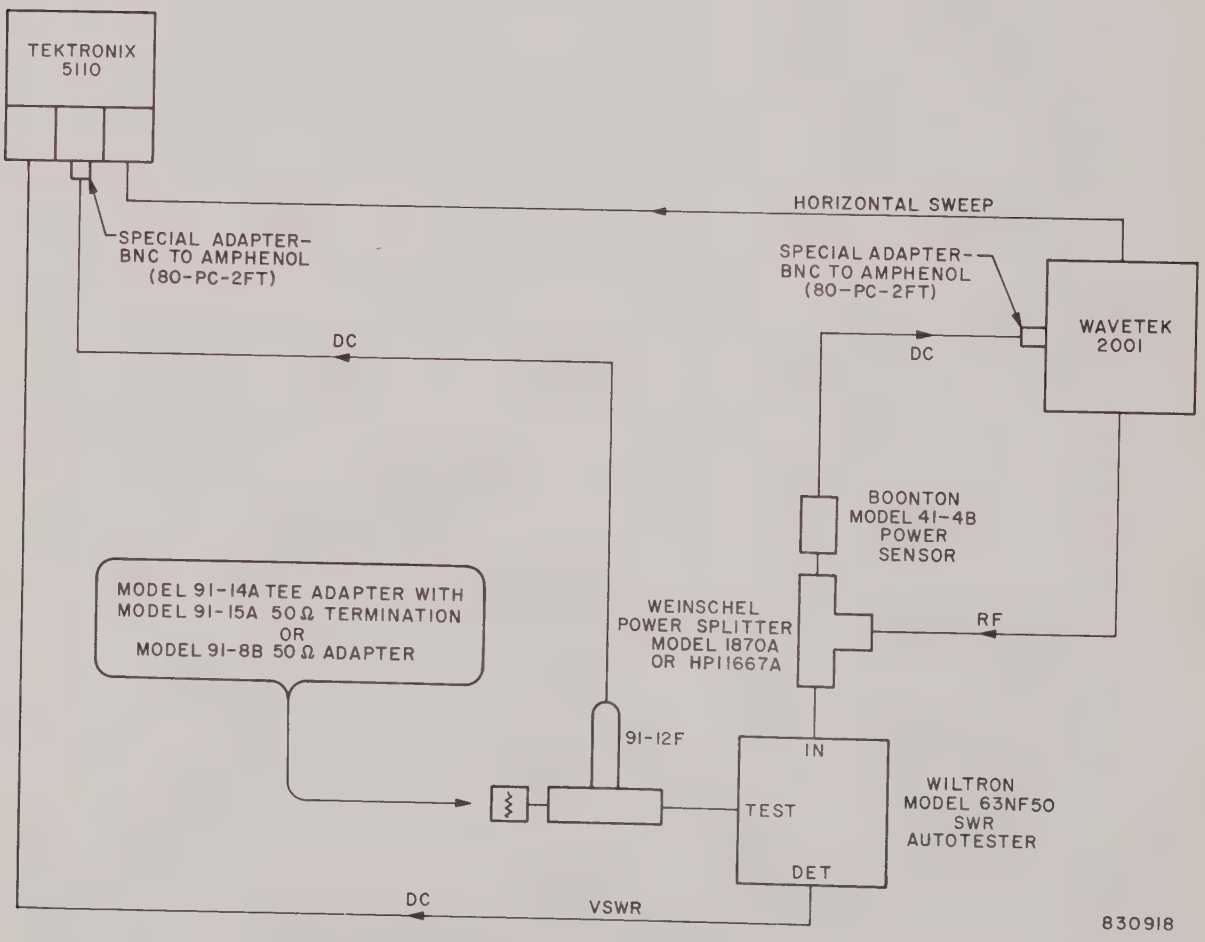


Figure 10. Swept Frequency-Response Test Setup

C. Frequency Response and S.W.R.

An alternate method of measuring both the frequency response and the s.w.r. (in terms of the reflection coefficient), but with somewhat reduced accuracy, employs a sweep generator, s.w.r. bridge, external levelling of the generator, power divider, and sensitive oscilloscope.

1. Test Equipment

a. Sweep Generator: Wavetek 2001 or H-P 8660 A/C, 0.01 to 2600 MHz.

b. S.W.R. Autotester: Wiltron Model 63NF50.

c. Oscilloscope: Tektronix Model 5110, with two 5A20 Vertical Amplifiers.

d. Power Splitter: Weinschel Model 1870A, or H-P 11667A.

e. Standard 1.2:1 Mismatch Termination: Weinschel Model M1410-1.2.

2. Test Procedure

a. Connect the equipment as shown in Figure 10, and temporarily connect the probe under test to the R.F. Millivoltmeter. Adjust the output control of the sweep generator for a reading on the S-1339A of 100 mV at a fixed frequency of 100 MHz.

b. Calibrate one of the vertical-input amplifiers of the oscilloscope for a sensitivity of 100 μV/div. The other vertical amplifier should be calibrated so that a change from 100 mV to 90 mV applied to the input of the probe under test will produce a vertical deflection of one division. This can be done easily if a Boonton Electronics Model 26A R.F. Millivoltmeter Calibrator is available. The probe should be temporarily connected to the output of the calibrator while output levels of 100 mV and 90 mV are alternately selected, and the sensitivity of the second input amplifier is adjusted for a deflection of one division.

c. Substitute the Standard 1.2:1 Mismatch Termination for the accessory under test, and calibrate the graticule of the oscilloscope for an s.w.r. of 1.2. Replace the accessory and probe.

d. Adjust the limits on the three bands of the sweep generator for coverage from 10 to 1200 MHz. Study the traces for both frequency response and s.w.r. (return loss).

e. Reverse the output ports of the power divider and repeat Steps (c) and (d).

f. It should be noted that the permissible error for the frequency-response trace expands with frequency. For the most meaningful results, the graticule should be marked with a grease pencil, showing the maximum permissible errors for the various frequency bands, as determined with a calibrated signal of, say, 1 MHz, and at levels above and below the selected test level. It is important to note that the recovered d.c. from the r.f. probe, which is applied to the second vertical amplifier, will vary as the square of the r.f. input level for test levels of 30 mV or less. Above 30 mV, the r.f.-to-d.c. conversion gradually changes from square law to linear, and approaches a peak-to-peak rectifier at in input of 3 volts.

NOTES

CHAPTER VI

INTERFACE

PROGRAMMING INPUTS AND DATA OUTPUTS

Pin No.	Function	Comment	Command	Unit Loading
7	Man. Disable	Disables front-panel range selection.	0	0.1
16	1 mV range	Selects range, provided that manual	0	0.1
15	3 mV "	disable has also been selected.	0	0.1
14	10 mV "	Selecting more than one range will	0	0.1
13	30 mV "	result in incorrect indications.	0	0.1
12	100 mV "	Range lines must be de-selected for	0	0.1
11	300 mV "	manual operation.	0	0.1
10	1 V "		0	0.1
9	3 V "		0	0.1
5	Common	Power-line ground at rear panel.	N/A	N/A
4	D.C. Analog	+10 V for full scale of "1" ranges; +9.5 V for "3" ranges.	N/A	N/A

Figure 11. Pin Designations

6.1 INPUT CHARACTERISTICS

TTL Series	Logic Level	Voltage Level	Curent per Unit Load
Standard Power 54/74	0	± 0.7 V	± 1.6 mA*
	1	2.4 to 5.25 V	40 µA

*The "-" current indicates current out of the input (external command device must this current). A standard power (Series 54/74) TTL output will sink and source 10 unit loads.

6.2 INPUT PULL-UP

All input terminals have internal pull-up. The current sourced by this pull-up when the input is brought to a logic level 0 is included in the loading shown in the "Unit Loading" Column of the chart.

6.3 ANALOG OUTPUT

Source resistance is 9 kΩ.

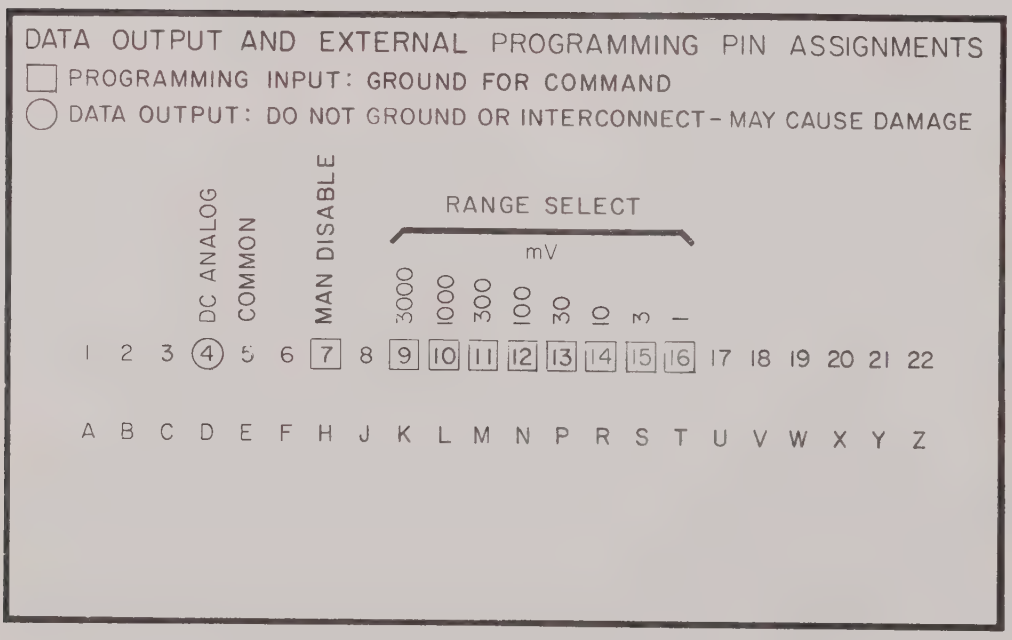

DATA OUTPUT AND EXTERNAL PROGRAMMING PIN ASSIGNMENTS
PROGRAMMING INPUT: GROUND FOR COMMAND
DATA OUTPUT: DO NOT GROUND OR INTERCONNECT - MAY CAUSE DAMAGE
DC ANALOG COMMON
MAN DISABLE
RANGE SELECT
mV
3000
1000
300
100
30
10
3
—
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22
A B C D E F H J K L M N P R S T U V W X Y Z

Figure 12. External Connections

TABLE OF REPLACEABLE PARTS

Reference		Description	Part No.
A201	Op. Amp.	LM310H	535005
A301	Op. Amp.	LM301AN	535012
C101	Capacitor, PE	100 nF, 10%, 200 V	234005
C102	Capacitor, Elec.	10 µF, 20%, 20 V	283205
C103	Capacitor, Mica	100 pF, 5%, 500 V	200001
C104	Capacitor, Elec.	10 µF, 20%, 20 V	283205
C105	Capacitor, Elec.	33 µF, 20%, 15 V	283206
C106	Capacitor, Elec.	10 µF, 20%, 20 V	283205
C107	Capacitor, Met.	1.0 µF, 20%, 100 V	236007
C108	Capacitor, Elec.	1.0 µF, 20%, 35 V	283199
C109	Capacitor, Elec.	50 µF, 25 V	283159
C110	Capacitor, Elec.	50 µF, 25 V	283159
C111	Capacitor, PE	100 nF, 10%, 200 V	234005
C112	Capacitor, Elec.	1000 µF, -10/+50%, 35 V	283350
C113	Capacitor, Elec.	1000 µF, -10/+50%, 35 V	283350
C114	Not Used		
C115	Capacitor, Cer.	0.001 µF, GMV, 500 V	224114
C116	Capacitor, Cer.	0.001 µF, GMV, 500 V	224114
C117	Not Used		
C118	Capacitor, Elec.	100 µF, 25 V	283105
C119	Capacitor, Elec.	100 µF, 25 V	283105
C120	Capacitor, Cer.	1 µF, 20%, 50 V	224264
C121	Capacitor, Cer.	1 µF, 20%, 50 V	224264
C201	Capacitor, PC	100 nF, 10%, 100 V	234046
C202	Capacitor,	6.8 nF, 10%,, 200 V	234044
C203	Capacitor, Mica	100 pF, 5%, 500 V	200001
C204	Capacitor, Mica	100 pF, 5%, 500 V	200001
C205	Capacitor, PE	22 nF, 10%, 200 V	230101
C206	Capacitor, PC	100 nF, 10%, 100 V	234046
C207	Capacitor, Mica	100 pF, 5%, 500 V	200001
C208	Capacitor, PC	100 nF, 10%, 100 V	234046
C209	Capacitor, Cer.	10 nF, 100 V	224119
C210	Capacitor, Cer.	10 nF, 100 V	224119
C211	Capacitor, PE	22 nF, 10%, 200 V	230101
C212	Capacitor, PC	470 nF, 10%, 50 V	234128
C213	Capacitor, Mica	100 pF, 5%, 500 V	200001
C214	Capacitor, Elec.	50 µF, 25 V	283159
C215	Capacitor, Elec.	50 µF, 25 V	283159
C216	Capacitor, Elec.	50 µF, 25 V	283159
C217	Capacitor, Elec.	150 µF, -10/+75%, 15 V	283307
C301	Capacitor, Cer.	10 nF, 100 V	224119
C302	Capacitor, Mica	33 pF, 5%, 500 V	200049
C303	Capacitor, Cer.	10 nF, 100 V	224119
C401	Capacitor, PC	100 nF, 10%, 100 V	234046
C402	Capacitor, PC	100 nF, 10%, 100 V	234046
CR101	Diode, Sig.	FDH300	530052
CR102	Diode, Sig.	1N914	530058
CR103	Diode, Sig.	1N914	530058
CR104	Diode, Zener	1N5243B (13 V)	530101
CR105	Diode, Zener	1N5235B (6.8 V)	530089

Reference	Description		Part No.
CR106 through CR110	Diode, Sig.	1N914	530058
CR111	Bridge, Rectifier	KBP02	532013
CR112	Bridge, Rectifier	KBP02	532013
CR113	Not Used		
CR114	Not Used		
CR115	Diode, Sig.	1N914	530058
CR116	Not Used		
CR117 through CR124	Diode, Sig.	1N914	530058
CR201 through CR218	Diode, Sig.	1N914	530058
CR219	Diode, Sig.	FDH300	530052
CR301 through CR308	Diode, Sig.	1N914	530058
CR401	Diode, LED	MV5025	536000
DS401	Lamp	Tungsol 349	545107
DS402	Lamp	Tungsol 349	545107
F401	Fuse	MDL 1/16 A, 250 V	545518
F402	Fuse, Slo-Blo	MDL 1/10 A, 250 V	545519
G401	Chopper	Special	540127
IC101	Regulator	µA7805UC	535011
IC102	Regulator	µA7805UC	535011
IC103	Not Used		
IC104	Regulator	LM723CN	535037
IC105	Regulator	LM723CN	535037
J101	Connector, Card Edge: 22-Pos., Amphenol 143-022-03		479231
J102	Connector, Card Edge: 22-Pos., Amphenol 143-022-03		479231
J401	Receptacle	BEC	092141
M401	Meter & Scale	API	554216
Q101	Transistor, FET	2N5949	528019
Q102	Transistor, FET	2N5949	528019
Q103	Not Used		
Q104	Transistor, FET	2N5949	528019
Q105	Transistor, FET	J231	528146
Q106	Transistor, FET	3N161	528132
Q107	Transistor, FET	3N161	528132
Q108	Transistor, FET	2N5949	528019
Q109	Transistor,	Selected	528044
Q110	Transistor, NPN	2N5088	528047
Q111	Transistor, PNP	2N5087	528042
Q112	Transistor, NPN-PNP	D39C2	528048
Q113	Transistor, PNP	2N5087	528042
Q114	Transistor, NPN	2N5088	528047
Q115	Transistor, FET	J231	528146

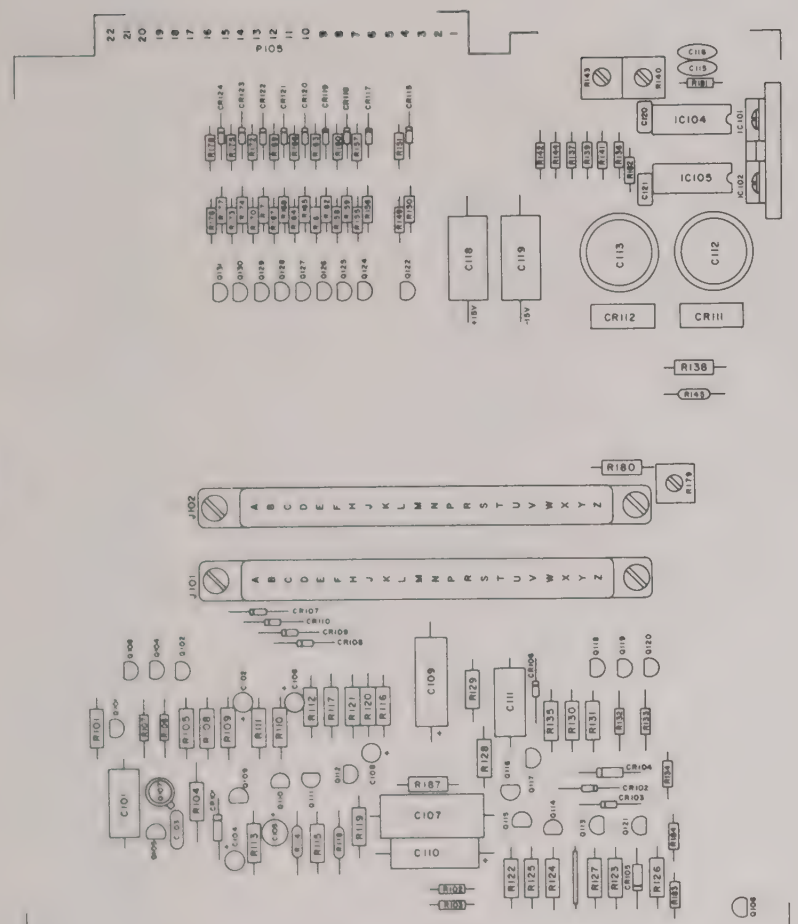
Reference	Description		Part No.
Q116	Transistor, FET	J231	528146
Q117	Transistor, FET	J231	528146
Q118	Transistor, FET	2N5949	528019
Q119	Transistor, FET	2N5949	528019
Q120	Transistor, FET	2N5949	528019
Q121	Transistor, PNP-PNP	D39C2	528048
Q122	Transistor, PNP	MPS-6516	528037
Q123	Not Used		
Q124 through Q131	Transistor, PNP	MPS-6516	528037
Q201	Transistor, Uni.	2N4871	528051
Q202	Transistor, NPN	MPS-A20	528043
Q203	Transistor, PNP	2N5087	528042
Q204	Transistor, NPN	2N5088	528047
Q205	Transistor, NPN	MPS-A20	528043
Q206	Transistor, FET	MPS-A12	528052
Q207	Transistor, NPN	MPS-A20	528043
Q208	Transistor, FET	J231	528146
Q209	Transistor, NPN	MPS-A20	528043
Q210	Transistor, FET	J231	528146
Q211	Transistor, FET	2N5949	528019
Q212	Transistor, NPN	MPS-A20	528043
Q213	Transistor, NPN	2N5308	528050
Q214	Transistor, NPN	2N5308	528050
Q301	Transistor, FET	2N5949	528019
Q302	Transistor, FET	2N5949	528019
Q303	Transistor, FET	2N5949	528019
Q304	Transistor, PNP	2N5087	528042
Q305	Transistor, FET	2N5949	528019
Q306	Transistor, PNP	2N5087	528042
Q307	Transistor, FET	2N5949	528019
Q308	Transistor, PNP	2N5087	528042
Q309	Transistor, FET	2N5949	528019
Q310	Transistor, PNP	2N5087	528042
Q311	Transistor, FET	2N5949	528019
Q312	Transistor, PNP	2N5087	528042
Q313 through Q316	Transistor, FET	2N5949	528019
Q317	Transistor, PNP	2N5087	528042
Q318	Transistor, NPN	2N5088	528047
Q319	Transistor, PNP	2N5087	528042
Q320	Transistor, NPN	2N5088	528047
Q321	Transistor, PNP	2N5087	528042
Q322	Transistor, PNP	2N5087	528042
Q323	Transistor, FET	2N5949	528019
Q324	Transistor, FET	2N5949	528019
Q325	Transistor, PNP	2N5087	528042
Q326	Transistor, FET	2N5949	528019
Q327	Transistor, PNP	2N5087	528042
Q328	Transistor, FET	2N5949	528019
Q329	Transistor, PNP	2N5087	528042
Q330	Transistor, FET	2N5949	528019

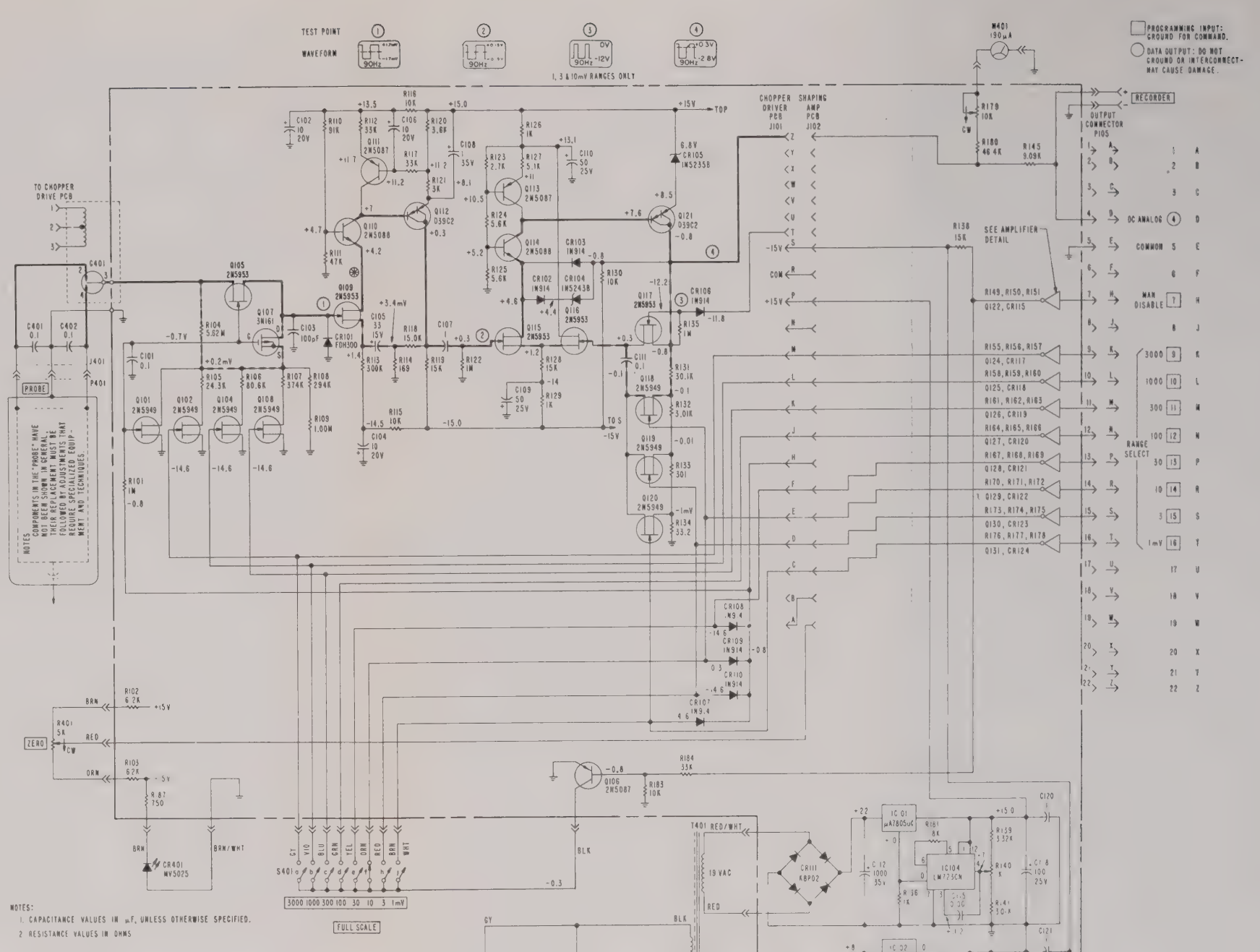
Reference	Description		Part No.
Q331	Transistor, FET	2N5949	528019
Q332	Transistor, PNP	2N5087	528042
Q333	Transistor, PNP	2N5087	528042
Q334	Transistor, PNP	2N5087	528042
Q335	Transistor, FET	2N5949	528019
Q336	Transistor, FET	2N5949	528019
Q337	Transistor, PNP	2N5087	528042
Q338	Transistor, PNP	2N5087	528042
Q339	Transistor, PNP	2N5087	528042
R101	Resistor, Comp.	1 MΩ, 5%	344600
R102	Resistor, Comp.	6.2 kΩ, 5%	343376
R103	Resistor, Comp.	6.2 kΩ, 5%	343376
R104	Resistor, MF	5.6 MΩ, 1%, 1/4 W	325397
R105	Resistor, MF	24.3 kΩ, 1%	341437
R106	Resistor, MF	80.6 kΩ, 1%	341487
R107	Resistor, MF	374 kΩ, 1%	341555
R108	Resistor, MF	294 kΩ, 1%	341545
R109	Resistor, MF	1.0 MΩ, 1%	342600
R110	Resistor, Comp.	91 kΩ, 5%	344492
R111	Resistor, Comp.	47 kΩ, 5%	344465
R112	Resistor, Comp.	33 kΩ, 5%	344450
R113	Resistor, Comp.	300 kΩ, 5%	344546
R114	Resistor, MF	169 Ω, 1%	341222
R115	Resistor, Comp.	10 kΩ, 5%	344400
R116	Resistor, Comp.	10 kΩ, 5%	344400
R117	Resistor, Comp.	33 kΩ, 5%	344450
R118	Resistor, MF	15 kΩ, 1%	341417
R119	Resistor, Comp.	15 kΩ, 5%	344417
R120	Resistor, Comp.	3.6 kΩ, 5%	344353
R121	Resistor, Comp.	3 kΩ, 5%	344346
R122	Resistor, Comp.	1 MΩ, 5%	344600
R123	Resistor, Comp.	2.7 kΩ, 5%	344341
R124	Resistor, Comp.	5.6 kΩ, 5%	344372
R125	Resistor, Comp.	5.6 kΩ, 5%	344372
R126	Resistor, Comp.	1 kΩ, 5%	344300
R127	Resistor, Comp.	5.1 kΩ, 5%	344368
R128	Resistor, Comp.	15 kΩ, 5%	344417
R129	Resistor, Comp.	1 kΩ, 5%	344300
R130	Resistor, Comp.	10 kΩ, 5%	344400
R131	Resistor, MF	30.1 kΩ, 1%	341446
R132	Resistor, MF	3.01 kΩ, 1%	341346
R133	Resistor, MF	301 Ω, 1%	341246
R134	Resistor, MF	33.2 Ω, 1%	341150
R135	Resistor, Comp.	1 MΩ, 5%	344600
R136	Resistor, Comp.	1 kΩ, 5%	343300
R137	Resistor, Comp.	1 kΩ, 5%	343300
R138	Resistor, Comp.	15 kΩ, 5%	344417
R139	Resistor, MF	3.32 kΩ, 1%	341350
R140	Resistor, Var.	1 kΩ, 10%, 1/2 W	311316
R141	Resistor, MF	3.01 kΩ, 1%	341346
R142	Resistor, MF	3.32 kΩ, 1%	341350
R143	Resistor, Var.	1 kΩ, 10%, 1/2 W	311316
R144	Resistor, MF	3.01 kΩ, 1%	341346
R145	Resistor, MF	9.09 kΩ, 1%	341392

Reference	Description		Part No.
R146 through R148	Not Used		
R149	Resistor, Comp.	160 kΩ, 5%	343520
R150	Resistor, Comp.	39 kΩ, 5%	343457
R151	Resistor, Comp.	100 kΩ, 5%	343500
R152 through R154	Not Used		
R155	Resistor, Comp.	160 kΩ, 5%	343520
R156	Resistor, Comp.	39 kΩ, 5%	343457
R157	Resistor, Comp.	100 kΩ, 5%	343500
R158	Resistor, Comp.	160 kΩ, 5%	343520
R159	Resistor, Comp.	39 kΩ, 5%	343457
R160	Resistor, Comp.	100 kΩ, 5%	343500
R161	Resistor, Comp.	160 kΩ, 5%	343520
R162	Resistor, Comp.	39 kΩ, 5%	343457
R163	Resistor, Comp.	100 kΩ, 5%	343500
R164	Resistor, Comp.	160 kΩ, 5%	343520
R165	Resistor, Comp.	39 kΩ, 5%	343457
R166	Resistor, Comp.	100 kΩ, 5%	343500
R167	Resistor, Comp.	160 kΩ, 5%	343520
R168	Resistor, Comp.	39 kΩ, 5%	343457
R169	Resistor, Comp.	100 kΩ, 5%	343500
R170	Resistor, Comp.	160 kΩ, 5%	343520
R171	Resistor, Comp.	39 kΩ, 5%	343457
R172	Resistor, Comp.	100 kΩ, 5%	343500
R173	Resistor, Comp.	160 kΩ, 5%	343520
R174	Resistor, Comp.	39 kΩ, 5%	343457
R175	Resistor, Comp.	100 kΩ, 5%	343500
R176	Resistor, Comp.	160 kΩ, 5%	343520
R177	Resistor, Comp.	39 kΩ, 5%	343457
R178	Resistor, Comp.	100 kΩ, 5%	343500
R179	Resistor, Var.	10 kΩ, 10%, 1/2 W	311328
R180	Resistor, MF	46.4 kΩ, 1%	341464
R181	Resistor, Comp.	1.8 kΩ, 5%	343325
R182	Resistor, Comp.	1.8 kΩ, 5%	343325
R183	Resistor, Comp.	10 kΩ, 5%	343400
R184	Not Used		
R185	Not Used		
R186	Not Used		
R187	Resistor, Comp.	750 Ω, 5%	344284
R201	Resistor, Comp.	10 kΩ, 5%	343400
R202	Resistor, Comp.	22 kΩ, 5%	344433
R203	Resistor, Comp.	10 kΩ, 5%	343400
R204	Resistor, Comp.	100 Ω, 5%	344200
R205	Resistor, Comp.	33 kΩ, 5%	344450
R206	Resistor, Comp.	10 kΩ, 5%	343400
R207	Resistor, Comp.	100 kΩ, 5%	343500
R208	Resistor, Comp.	3.3 kΩ, 5%	344350
R209	Resistor, Comp.	4.7 kΩ, 5%	344365
R210	Resistor, Comp.	10 kΩ, 5%	343400

Reference		Description	Part No.
R211	Resistor, Comp.	150 kΩ, 5%	344517
R212	Resistor, Comp.	10 kΩ, 5%	344400
R213	Resistor, Comp.	10 kΩ, 5%	344400
R214	Resistor, Comp.	22 kΩ, 5%	344433
R215	Resistor, Comp.	10 kΩ, 5%	344400
R216	Resistor, Comp.	270 kΩ, 5%	344541
R217	Resistor, Comp.	240 kΩ, 5%	344537
R218	Resistor, Comp.	10 kΩ, 5%	344400
R219	Resistor, Comp.	15 kΩ, 5%	344417
R220	Resistor, Comp.	10 kΩ, 5%	344400
R221	Resistor, Comp.	10 kΩ, 5%	344400
R222	Resistor, Comp.	10 kΩ, 5%	344400
R223	Resistor, Comp.	4.7 kΩ, 5%	344365
R224	Resistor, Comp.	12 kΩ, 5%	344408
R225	Resistor, Comp.	100 kΩ, 5%	344500
R226	Resistor, Comp.	100 kΩ, 5%	344500
R227	Resistor, Comp.	15 kΩ, 5%	344417
R228	Resistor, Comp.	10 kΩ, 5%	344400
R229	Resistor, Comp.	100 kΩ, 5%	344500
R230	Resistor, Comp.	12 kΩ, 5%	344408
R231	Resistor, Comp.	4.7 kΩ, 5%	344365
R232	Resistor, Comp.	100 kΩ, 5%	344500
R233	Resistor, Var.	2 kΩ, 20%, 1/2 W	311285
R234	Resistor, Comp.	100 kΩ, 5%	344500
R235	Resistor, Comp.	100 kΩ, 5%	344500
R236	Resistor, Comp.	27 kΩ, 5%	344441
R237	Resistor, Comp.	100 kΩ, 5%	344500
R238	Resistor, Comp.	100 kΩ, 5%	344500
R239	Resistor, Comp.	1.6 kΩ, 5%	344320
R240	Resistor, Comp.	300 Ω, 5%	344246
R241	Resistor, Comp.	200 Ω, 5%, 1 W	302082
R242	Resistor, Comp.	150 kΩ, 5%	344517
R243	Resistor, Comp.	510 kΩ, 5%	344568
R244	Resistor, Var.	50 kΩ, 20%, 1/2 W	311282
R245	Resistor, Comp.	47 Ω, 5%	344165
R301	Resistor, Comp.	130 Ω, 5%	344211
R302	Resistor, Comp.	4.7 MΩ, 5%	344665
R303	Resistor, Var.	1 kΩ, 10%, 1 W	311256
R304	Resistor, MF	10 kΩ, 1%	341400
R305	Resistor, Comp.	4.7 MΩ, 5%	344665
R306	Resistor, MF	51.1 kΩ, 1%	341468
R307	Resistor, MF	2.49 kΩ, 1%	341338
R308	Resistor, Var.	1 kΩ, 10%, 1 W	311256
R309	Resistor, MF	28.7 kΩ, 1%	341444
R310	Resistor, MF	210 kΩ, 1%	341531
R311	Resistor, MF	100 kΩ, 1%	341500
R312	Resistor, MF	42.2 kΩ, 1%	341460
R313	Resistor, MF	191 kΩ, 1%	341527
R314	Resistor, MF	11 kΩ, 1%	341404
R315	Resistor, Comp.	4.7 MΩ, 5%	344665
R316	Resistor, MF	29.4 kΩ, 1%	341445
R317	Resistor, MF	95.3 kΩ, 1%	341494
R318	Resistor, Var.	1 kΩ, 10%, 1 W	311256
R319	Resistor, MF	27.4 kΩ, 1%	341442
R320	Resistor, MF	64.9 kΩ, 1%	341478

Reference	Description		Part No.
R321	Resistor, MF	1.00 MΩ, 1%	342600
R322	Resistor, MF	26.1 kΩ, 1%	341440
R323	Resistor, MF	46.4 kΩ, 1%	341464
R324	Resistor, MF	10 kΩ, 1%	341400
R325	Resistor, Comp.	4.7 MΩ, 5%	344665
R326	Resistor, MF	45.3 kΩ, 1%	341463
R327	Resistor, MF	2.49 kΩ, 1%	341338
R328	Resistor, Var.	1 kΩ, 10%, 1 W	311256
R329	Resistor, Comp.	390 kΩ, 5%	344557
R330	Resistor, MF	21.5 kΩ, 1%	341432
R331	Resistor, MF	240 kΩ, 1%	341536
R332	Resistor, Comp.	22 kΩ, 5%	344433
R333	Resistor, MF	26.1 kΩ, 1%	341440
R334	Resistor, MF	150 kΩ, 1%	341517
R335	Resistor, Comp.	47 kΩ, 5%	344465
R336	Resistor, MF	54.9 kΩ, 1%	341471
R337	Resistor, MF	178 kΩ, 1%	341524
R338	Resistor, Comp.	4.7 MΩ, 5%	344665
R339	Resistor, MF	82.5 kΩ, 1%	341488
R340	Resistor, MF	178 kΩ, 1%	341524
R341	Resistor, Var.	1 kΩ, 10%, 1 W	311256
R342	Resistor, MF	17.8 kΩ, 1%	341424
R343	Resistor, MF	2.74 kΩ, 1%	341342
R344	Resistor, Comp.	4.7 MΩ, 5%	344665
R345	Resistor, MF	24.3 kΩ, 1%	341437
R346	Resistor, MF	232 kΩ, 1%	341535
R347	Resistor, Var.	1 kΩ, 10%, 1 W	311256
R348	Resistor, MF	95.3 kΩ, 1%	341494
R349	Resistor, MF	453 kΩ, 1%	341563
R350	Resistor, Comp.	4.7 MΩ, 5%	344665
R351	Resistor, MF	200 kΩ, 1%	341529
R352	Resistor, MF	634 kΩ, 1%	342577
R353	Resistor, Var.	1 kΩ, 10%, 1 W	311256
R354	Resistor, MF	14.3 kΩ, 1%	341415
R355	Resistor, MF	2.49 kΩ, 1%	341338
R356	Resistor, MF	34.8 kΩ, 1%	341452
R357	Resistor, MF	523 kΩ, 1%	342569
R358	Resistor, Comp.	4.7 MΩ, 5%	344665
R359	Resistor, MF	162 kΩ, 1%	341520
R360	Resistor, MF	806 kΩ, 1%	342587
R361	Resistor, MF	10 kΩ, 1%	341400
R362	Resistor, MF	2.74 kΩ, 1%	341342
R363	Resistor, Var.	1 kΩ, 10%, 1 W	311256
R364	Resistor, MF	127 kΩ, 1%	341510
R365	Resistor, MF	604 kΩ, 1%	342575
R401	Resistor, Var.	5 kΩ, 20%, 2 W	311255
RT301	Thermistor	100 Ω, 10%	325005
S401	Switch	Pushbutton	465146
S402	Switch	Slide	465134
T401	Transformer	Power	446068



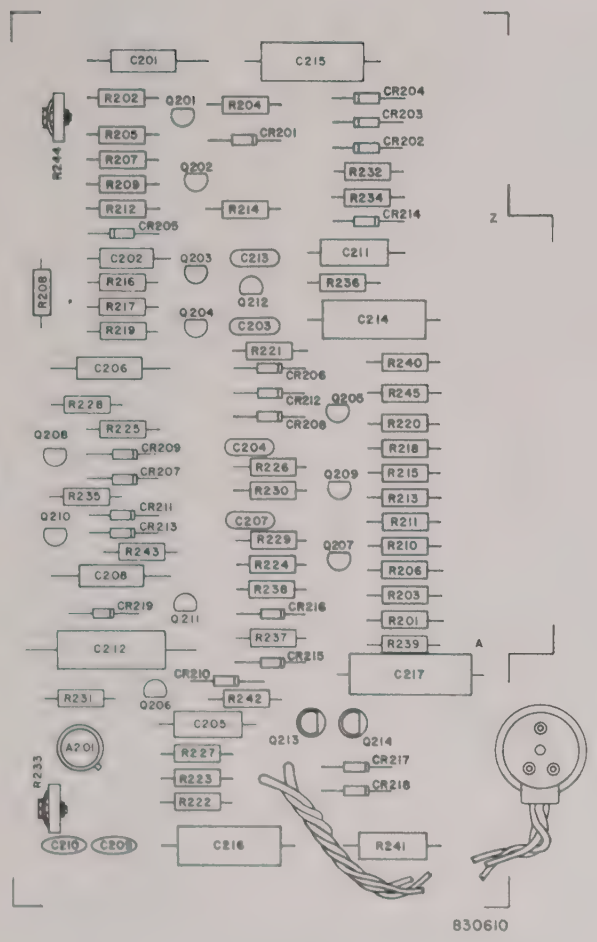


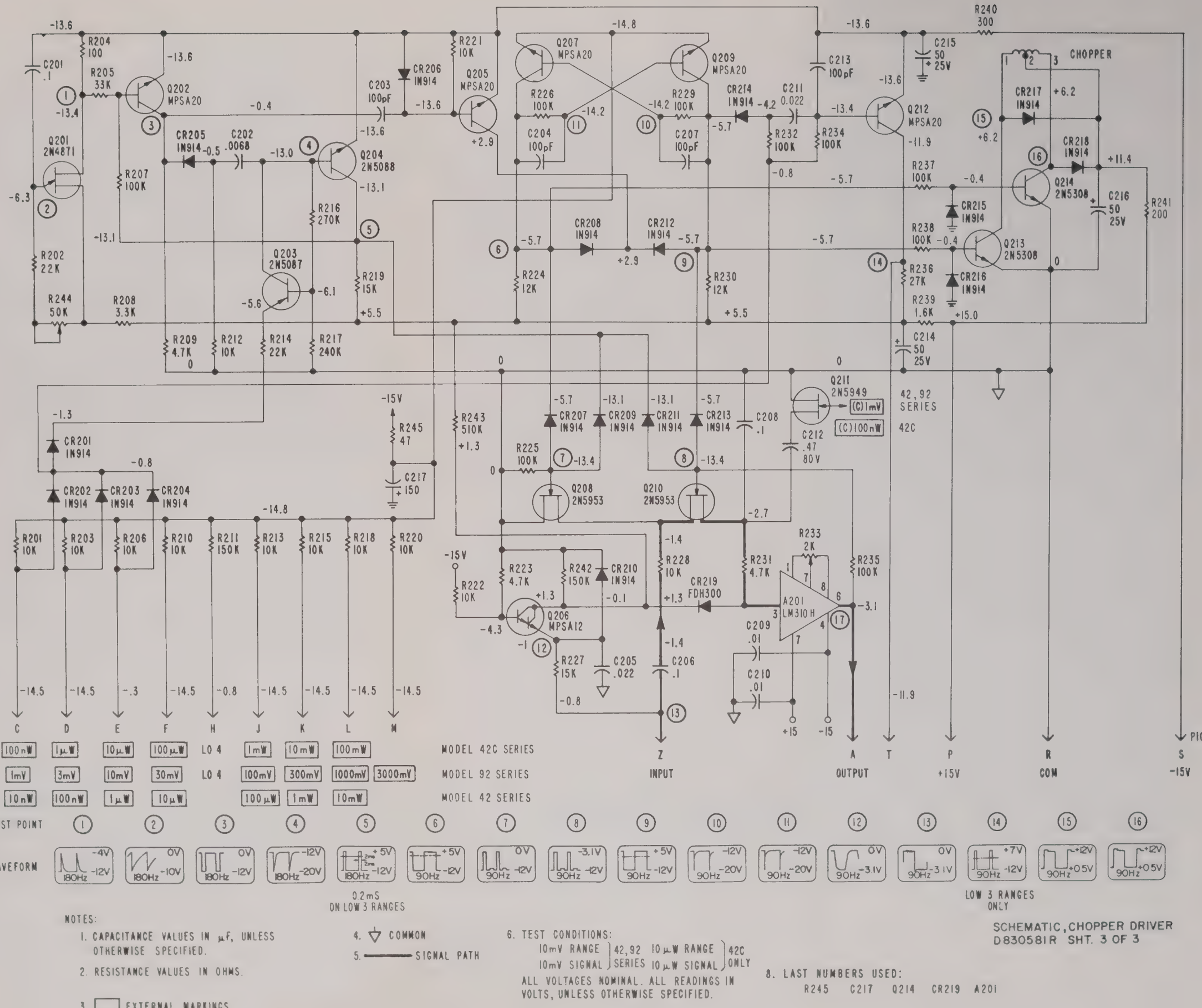
NOTES:
1. CAPACITANCE VALUES IN µF, UNLESS OTHERWISE SPECIFIED.
2 RESISTANCE VALUES IN OHMS

4. ⊛ FACTORY SELECTED VALUE.
5. ▭ EXTERNAL MARKINGS.
6. ——— SIGNAL PATH.
7. ——— FEEDBACK PATH.
8. ——— SIGNAL PATH FOR 100, 300, 1000 & 3000mV RANGES ONLY.
9. TEST CONDITIONS.
   RANGE 10mV
   SIGNAL 10mV
   ALL VOLTAGE READINGS IN VOLTS, UNLESS OTHERWISE SPECIFIED. ALL READINGS NOMINAL.
10. LAST NUMBERS USED
    R187 C121
    R401 C402 CR401
11. NUMBERS NOT USED
    R152 R153 R154 R185 R186
    Q123 CR116

AMPLIFIER DETAIL

SCHEMATIC, AMPLIFIER P.C. BD
E030805L





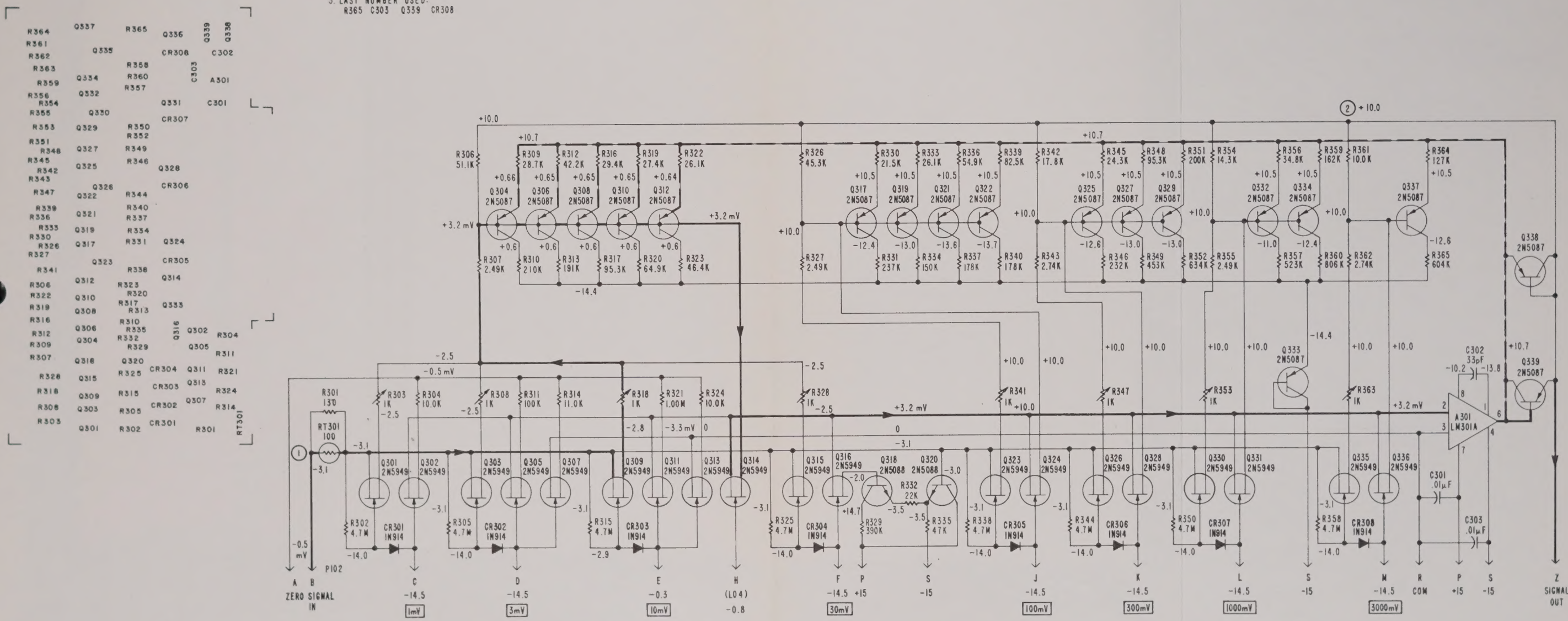
NOTES:

1. CAPACITANCE VALUES IN μF, UNLESS OTHERWISE SPECIFIED.
2. RESISTANCE VALUES IN OHMS.
3. ▭ EXTERNAL MARKINGS.
4. ⏚ COMMON
5. ——— SIGNAL PATH
6. TEST CONDITIONS:
   - 10mV RANGE / 10mV SIGNAL (42,92 SERIES)
   - 10μW RANGE / 10μW SIGNAL (42C ONLY)

   ALL VOLTAGES NOMINAL. ALL READINGS IN VOLTS, UNLESS OTHERWISE SPECIFIED.
8. LAST NUMBERS USED:
   R245 C217 Q214 CR219 A201

SCHEMATIC, CHOPPER DRIVER
D830581R SHT. 3 OF 3

NOTES:
1. RESISTANCE VALUES IN OHMS.
2. SIGNAL PATH ——
3. FEEDBACK PATH — — —
4. ▭ EXTERNAL MARKINGS
5. LAST NUMBER USED:
   R365 C303 Q339 CR308



SCHEMATIC, SHAPING AMP
D830456P, SHT. 3 of 3

WARRANTY

Boonton Electronics Corporation warrants its products to the original purchaser to be free from defects in material and workmanship and to operate within applicable specifications for a period of one year from date of shipment, provided they are used under normal operating conditions. This warranty does not apply to active devices that have given normal service, to sealed assemblies which have been opened or to any item which has been repaired or altered without our authorization.

We will repair, or at our option, replace any of our products which are found to be defective under the terms of this warranty.

There will be no charge for parts, labor, or forward and return shipment during the first three months of this warranty.

There will be no charge for parts, labor, or return shipment during the fourth through twelfth month of this warranty.

Except for such repair or replacement, we will not be liable for any incidental damages or for any consequential damages, as those terms are defined in Section 2-715 of the Uniform Commercial Code, in connection with products covered by this warranty.

BOONTON

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